REPORT OF THE COMMITTEE

ON

WATER SUPPLY AND DRAINAGE

OF

THE TOWN OF MILLBURY,

MARCH, 1888.

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BOSTON:
RAND AVERY COMPANY, PRINTERS.
1888.

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REPORT.

To the Citizens of the Town of Millbury.

At the annual town-meeting holden March 21, 1887, the following vote was passed: —

"*Whereas*, the Legislature has been asked to incorporate a private company to furnish a water supply for the town, and

"*Whereas*, the town desires steps to be taken with a view to such supply being furnished, if at all, by and under the control of the town,

"*Resolved*, That a committee of five be appointed to consider and report upon the whole question of a water supply for the town, to consider the several sources of supply, to consider the disposal of sewage, and particularly to ask for bids and plans from all desiring to compete.

"*Resolved*, That the selectmen be instructed to ask the next General Court for the authority which it may be necessary for the town to have in the premises.

"*Resolved*, That the town instruct the selectmen to oppose the granting of any charter to any private corporation for the purpose of supplying the town with water."

The Committee appointed in conformity to this vote submit the following report: —

At the outset of our investigation of the questions submitted to us, we were met by the natural and pertinent inquiry, "Does the town need a public water supply?" If, of course, it could be shown that our present supply is good enough, both in quantity and quality, the town would not be

justified in assuming so large an obligation as the construction of water-works would necessarily involve. If, on the other hand, it could be shown that our present supply is insufficient, or impure and unwholesome, and especially if the impurities were such as involve danger to health, it would then be generally allowed that the matter of securing a public supply that should be both sufficient and wholesome should be most seriously considered.

So far as sufficiency is concerned, our present supply is no doubt generally (with occasional exceptions in dry seasons) ample for all domestic uses; but all recognize a great insufficiency for the extinguishment of fires, a matter of immense importance.

Of even greater importance is the question of the purity of our water supply, which is, as all know, from wells dug in quite close proximity to our dwellings, their surroundings being such as is usual in all New-England villages, so that they are liable to contamination from sink spouts, leaky drains, cesspools, privies, pig-pens, or barns.

That this liability is not simply theoretic, has been amply proven by the investigations of the Massachusetts State Board of Health.

In the report of that Board for 1873, on p. 35 they say, "A neglected privy in the neighborhood of a well, or any privy within thirty or forty feet of a well in soils of ordinary porosity, will affect the purity of the water, as may be seen by careful analysis at any time, and as may be demonstrated, when least expected, by fevers, dysenteries, and intestinal disorders."

In the report of the Board for 1876, p. 191 *et seq.*, in the article on "Water Supply and Drainage from the Sanitary Point of View," appears the following: "There are three forms of water supply, — wells, cisterns, aqueducts. Of these the first has, of course, been that in general use in Massachusetts, as it must long continue to be in most towns not closely built up. To what forms of pollutions it is exposed,

from privies, 'sinks,' cesspools, stables, etc., has been shown under a previous head. Whenever dwellings are within one hundred feet of each other, even on a level surface, there is danger that one may pollute the other's well, through some one of the above-named agencies."

It, moreover, often happens that people consider themselves free from any danger because they detect nothing unpleasant either in the appearance, odor, or taste of the water from their wells. It is unfortunately true that these things furnish no criterion by which the purity of a water can be judged.

Upon this point the State Board of Health, in its report for 1876, says, "The fact that a water is clear and palatable is no proof whatever of its purity, these conditions being markedly present in some well-waters shockingly polluted with sewage." And in the report for 1878 we find the following (p. 54): —

"It has been clearly shown, by these investigations, that a dangerous pollution may exist in drinking-water without its presence being revealed in any way to even the practised sense, unaided by chemical examination." On p. 77 of the same report appears the following: "Wells cannot be depended upon for supplies of wholesome water unless they are thoroughly guarded from sources of surface and subsoil pollution. Some of the foulest well-water examined by the Board has been clear, sparkling, and of not unpleasant taste."

With a knowledge of such general facts, your Committee, for the purpose of gaining a more exact knowledge of the facts in our own town, procured the analysis of water from twelve wells in various parts of Bramanville and the lower villages. To these analyses were added those of four others, obtained by private individuals for their own benefit; and besides these, the general conclusions of the chemist upon still another well, though the analysis itself was not obtained. Thus we have a series of seventeen analyses of wells, of

which five were situated in Bramanville, and twelve in the lower villages, situated on the following streets; viz., Elm, Main, South Main, Maple, Church, Cherry, Grove, Summer, and Miles Streets.

Without giving the analysis in tabular form, which would have little significance to most persons, the important facts revealed are, that, of these seventeen wells, five only are pure and entirely safe for use, the remaining twelve being either suspicious or positively bad. Of the five good wells, two are on the edges of the villages, and one, while now pure, can only remain so by the greatest watchfulness, and is liable at any time to serious contamination. It should be further stated that these wells were selected at random, and without the design to find bad wells. They are for the most part wells on the premises of our best and most careful citizens, and no doubt fairly represent the condition of wells throughout the town. So, then, it seems probable that at least two-thirds of our wells are unsafe sources of water supply. Several of our citizens have abandoned the use of their wells; while, as is well known, one of the largest manufacturing corporations in town, distrusting their wells, have at large expense constructed works of their own to supply their mill and their tenants with pure water, — a privilege they have extended to a few of our citizens also, while they have had applications from many more for a like supply.

Your Committee feel that the facts elicited by their inquiry justify them in the conclusion that the present water supply of the town is inadequate in quantity, and unsatisfactory and even unsafe as to quality, and that the town therefore needs a public water supply. Convinced of this, the remaining question of source of supply could be satisfactorily determined only by the investigations of a competent engineer.

To secure such investigations and surveys which should be of permanent value, and available whenever the town should decide to enter upon the construction of works, your

Committee secured the services of Mr. Percy M. Blake, C.E., of Hyde Park, who has had large experience in such matters. His report, which covers all the ground of available sources, — the range of service and fire protection, method and cost of construction and maintenance, as well as of probable income, — is presented for your information, together with this report. His report was accompanied by a map setting forth the whole plan, which could not well be reduced and reproduced for publication. It is, however, in the hands of the Committee, and available whenever needed.

Regarding the sources of supply, your Committee made some investigations upon matters only incidentally referred to in the report of the engineer.

It was understood by the Committee that many citizens favored Singletary Pond as the source of supply, if the water could be taken without subjecting the town to too heavy damages for injury to mill-owners below. Upon this point your Committee submitted the question for a legal opinion, which was given as follows: —

MILLBURY, MASS., July 11, 1887.

TO THE COMMITTEE ON WATER SUPPLY FOR THE TOWN OF MILLBURY.

Gentlemen, — I understand the question submitted to me for an opinion to be this: —

Would it be competent for the General Court to grant to the town of Millbury the right to take the waters of Singletary Pond for the extinguishment of fires, and for domestic and other purposes, without providing, in the grant, compensation for persons and corporations injuriously affected in property by the diminution in the volume of water that otherwise would flow in the natural outlet of the pond?

The rights of riparian owners upon natural streams are well settled. They have the right to the reasonable use of the water flowing in the stream and to its natural flow. This right is a species of property.

A grant to the town to take the waters of a great pond, in effect, appropriates the water which otherwise would flow from it down the stream, to the use of the public, and deprives the riparian of it.

"And whenever the public exigencies require that the property of an individual should be appropriated to public use, he shall receive a reasonable compensation therefor." — *Declaration of Rights, Mass. Con., Article X.*

I am of the opinion that a grant to the town which does not provide compensation for riparian proprietors would be unconstitutional.

Since 1870 the General Court has passed two hundred and fifty Acts authorizing cities and towns and associations of individuals to take great ponds and other sources of supply for the purpose of extinguishing fires, and for domestic and other purposes.

An examination of these Acts shows that it has been the policy of the Commonwealth to recognize the rights of riparian owners and of all persons affected by the taking of water.

The usual provision is, that "the said corporation shall pay all damages sustained by *any person* in property by the taking of any land, right of way, water, water source, water right, or easement, or by any other thing done by the said corporation."

Assuming that a like provision would be incorporated in any grant which the town might obtain to take Singletary Pond, I am of the opinion, —

(1) That the mill-owners and others upon the Singletary Stream would have a right to reasonable compensation for any diminution of the supply of water in the stream resulting from the taking of the source of supply by the town; and (2) that the riparian owners on the Blackstone River, below the junction of Singletary Stream with it, would have a right to reasonable compensation for any damage they might prove, resulting from the taking of the pond.

Respectfully,

JOHN HOPKINS.

From this, while it does not attempt to estimate the probable amount of damages, it is the judgment of your Committee, in the light of the awards in the case of the Rhode Island Manufacturers *vs.* the City of Worcester, in a wholly similar matter, that the town cannot look to Singletary Pond as its source of supply, except possibly as a supplementary source at some quite remote future time, when the needs of the town shall become much more than now, and its ability to meet the needful expense also much greater.

With regard to a connection with the water-works of the city of Worcester as a source of supply, your Committee conferred with the authorities of the city during the last summer, and, to bring the matter definitely before them, formally petitioned the city to furnish the town of Millbury with water through works to be constructed by the town.

At a meeting of the Joint Standing Committee on Water of the city holden on Feb. 21, it was voted "that it was not advisable to recommend any action at present to furnish the town of Millbury with water." It was also further voted "to report giving the town of Millbury leave to withdraw."

It is, however, understood that the city is not averse to the project, and that the plan is regarded as wholly feasible, and the supply of water abundantly ample for all probable wants of both communities.

This plan possesses so many advantages, that it deserves most careful consideration.

It is fully discussed in the accompanying report of the engineer as to construction, operation, cost, etc.

For the more intelligent understanding of the question of a public water supply, your Committee present the following facts regarding similar enterprises in other places: —

In 1887 there were in New England 233 cities and towns furnished with a public water supply. In Massachusetts there were 128, and several have been added since. Among these 128 there were about 70 towns of less than 5,000 population so furnished.

In all these 70 towns except one, so far as figures on this point are available, it appears that the income from the works has exceeded the annual cost, although in this statement the interest on the water debt is not included in the annual cost; but in a large number of these towns the revenue is more than sufficient to meet all the annual cost, including the interest on the water debt.

The subject of sewerage and sewage disposal has been considered by your Committee, and the engineer's report thereon is presented herewith.

This subject has an important bearing on the question of a public water supply; for if the construction of a system of sewers must be undertaken immediately upon the introduction of water, it, of course, involves a very heavy cost, from which no revenue can be expected.

This cost, according to the estimates of our engineer, would be about $96,000.

In the opinion of our engineer, the immediate construction of sewers would not be necessary: indeed, the introduction of a public water supply would obviate one of the chief necessities for a system of sewerage; namely, the liability to contamination of drinking-water, no longer obtained from wells, by sink spouts, cesspools, etc.

The avoidance of such contamination and of soil dampness is the occasion whence arises the necessity for sewers. On general principles, the introduction of water would tend to increase soil dampness from the much freer use which would be made of water; but the situation of our town is such that the natural grades would, to a very large degree, protect us from this danger.

Your Committee recognize the fact that ultimately a system of sewers may become a necessity, especially should the town grow much, but do not believe that there would be any immediate necessity for their construction. It is to be further said, that, when such construction must be undertaken, the whole work need not be undertaken at once, but only such

parts of it as density of population requires; and the system could be extended from time to time, as circumstances should demand. It is believed that it is entirely feasible to conduct the sewage of the town, through properly constructed sewers, to, and to distribute it upon, certain tracts of low land of favorable situation and favorable character of soil, below the mill of Capt. P. Simpson, upon the opposite side of the river, where it might be used upon a sewage farm, such as has been successfully operated in other places. This plan, if adopted, would cost probably about $96,000 if the whole system were undertaken at once: but the necessities of the case would call for the expenditure of only a small fraction of this amount from year to year, were the system only gradually developed, as is done almost universally elsewhere; large tracts of the city of Worcester, for instance, were not connected with the sewer system for many years after the system was adopted and its construction begun.

Regarding the disposal of sewage, the Committee would strenuously insist that no plan contemplating its discharge into the Blackstone River or other stream or body of water should ever be adopted.

RECOMMENDATIONS OF THE COMMITTEE.

First, The Committee believes that the best interests of our town demand a public water supply, and recommend that this enterprise be undertaken at no distant time.

Second, We recommend the adoption of the plan referred to in the engineer's report as the "Local Pumping Plan," so far as the construction of a well near the Boston and Albany Railroad, and the necessary pumping station, the laying of mains in our streets, with the necessary gates, hydrants, etc., and the building of the necessary reservoir upon Burbank Hill. This much, it is believed, would be adequate for all the wants of the town for many years, at least until our present population is doubled, and would furnish water of great purity.

The Committee wishes, however, to qualify this recommendation by advising that the plan for a connection with the Worcester Water Works, which seems for the present to be unavailable, be further carefully considered, and the privilege of such connection be earnestly sought, before finally adopting the "Local Pumping Plan," since a connection with the Worcester Works furnishes a surer guaranty for an adequate supply of water, not only for the present, but for any future growth of the town.

Third, In the matter of sewers, we recommend that no construction of a system of sewers be undertaken at present, but that some suitable plan for such system be at once adopted, and that grade plans for such system be at once procured, and that, in the language of the engineer, "the repairs of street surfaces hereafter be made in accordance with such plans, with a view to securing good surface drainage, and avoiding future expense."

In making the investigations of the matters committed to us by the town, the Committee has made the following expenditures: —

For analysis of well-waters . . .	$96 00
engineers for survey and report . .	620 00
engineers for sinking test-wells . .	150 00
	$866 00

All which is respectfully submitted.

JOHN GEGENHEIMER,
LEVI L. WHITNEY,
IRVING B. SAYLES,
GEORGE C. WEBBER,
Committee on Water Supply and Drainage.

I concur in the above report, except that I do not join in making any "recommendations" to the town regarding its action with reference to the matters considered.

MOSES W. WHEELER,
One of the Committee.

MILLBURY, March 1, 1888.

To JOHN GEGENHEIMER, MOSES W. WHEELER, L. L. WHITNEY, IRVING B. SAYLES, GEORGE C. WEBBER, *Committee on Water Supply and Drainage, Millbury, Mass.*

Gentlemen, — I have the pleasure of presenting the following report on the subject of a public water supply for the town of Millbury.

The facts and figures obtained and presented herein will be found in the form of tabulated distances and levels, following the text of the report.

The obtaining and arranging of these somewhat complicated data has consumed much more time than was anticipated, and the study of them has been repeatedly interrupted by many engagements undertaken and entered upon prior to the request of your Committee for this special investigation.

With a knowledge, gained by experience, of the importance of reliable information in a case like this, I have not felt like transmitting to you a report, or any portion thereof, on this project, until I could give it that final study and arrangement which alone would be satisfactory to you.

The term "public water supply" describes one of the most important public improvements which a town can undertake. The relations of such a water supply to private, corporate, and manufacturing interests are of a most practical nature; and this is shown in no more conclusive way than in the almost universal adoption, by householders, manufacturing and business concerns, merchants, and public corporations, of the conveniences, safeguards, and economy of a competent water service.

I do not think you will consider it necessary for me to give in detail the many special applications of a public water supply, as it is but reasonable to suppose that your citizens are generally familiar with the most important, at least, of these applications.

There are, however, two primary advantages to be gained in the introduction of water under a modern system, which are of such great value to any community as to warrant frequent mention, and to these I will briefly call your attention.

The first is, the value of pure water for drinking-purposes.

The second, the protection of property from destruction by fire.

It has for many years been agreed and accepted as a fact beyond dispute that the two elements of greatest general importance influencing a local standard of health are the air which is breathed, and the water which is used for drinking and culinary purposes.

Except in rare and peculiar cases, no one need suffer for want of pure and suitable air to breathe. There is always plenty of it to be had by opening doors or windows, and, except in districts locally polluted by offensive surface wastes or manufacturing stinks, the air contains life-sustaining qualities.

In regard to the water used for drinking-purposes as obtained by individual effort from ordinary wells and cisterns, the exceptions from favorable conditions are far greater and more serious in the danger they threaten to consumers.

A single illustration, many applications of which will no doubt occur to your citizens as existing under their own observations, will suffice to emphasize this latter statement.

The average house-lot on a village street contains about eight thousand (8,000) square feet of land. As found by actual investigation in such villages, not less than seven in every ten such house-lots contain a well, vault, and cesspool, or other receptacle for house wastes, all within a circle having a diameter of less than fifty feet.

From the well thus located, all the drinking-water used by the family is taken, and suspicion as to the quality of this water is seldom aroused until offensive tastes or smells are perceived in its use.

So long as such a well yields water that can be drunk, the family supply is taken therefrom by laborious pumping, or dipping up with the old-fashioned bucket, and the family filth is hurried out of sight into the porous soil to assist in replenishing the well.

That this is not a strained statement can be readily understood from the following conditions, which must exist in all such cases: —

First, the surface of the water in the well is almost invariably lower than the bottom of the adjoining vault and cesspool. Sometimes this water surface is twenty feet below the bottom of such vault and cesspool.

Second, the liquid wastes deposited in these receptacles of filth are constantly disappearing by subsidence into the soil, leaving the solid matters quite dry.

Third, in the course of a year many hundred times the amount of liquid wastes which these receptacles will at any one time hold, are deposited therein, and disappear by this subsidence process.

Fourth, if there is any change in the character of these liquid wastes as they settle through the ground toward and into the well, it must be due wholly to the purifying services of the soil through which they pass.

Fifth, the fact, then, must be, that the only protection the well has in such a case is the ability of the soil to thoroughly and continually purify these waters, by holding back all rank germs of disease and acute essences of putrefaction.

It is well known, or should be, that the sense of taste frequently fails to discover the presence of injurious pollutions of this nature in drinking-water, so that great harm is threatened those who do not carry investigation as to the purity of local well waters beyond the sensitiveness of the palate.

Of the water obtained by storing the drainage from roofs in closed cisterns, the following facts are known: —

First, whatever dust, decay, or other filth may accumulate on the roof or in the gutters of a building is thoroughly

washed off, and conveyed directly to the cistern when rain falls. Though perhaps small in amount at any one time, yet long-continued accumulations of this character eventually render cistern water rank and offensive. Especially is this noticeable after a long dry period, when the rapid filling-up of the cistern from a heavy rainstorm agitates the water, and disturbs the sediment. The stale, stagnant taste of many cistern waters indicates the doubtful quality of the water obtained in this way.

Filtration through porous brickwork improves to some extent the quality of cistern water; but the fact remains, that some filth does get into the best cistern from the sources and in the way described.

Of the degree and amount of injury to the health of consumers wrought by the impure condition of well and cistern waters, much might be said; but it appears to me that the facts universally known in regard to this subject are so many, and have been so ably discussed and presented to the people of Massachusetts by the official Boards of Health during the last twelve years, that to further attempt by argument to establish accepted conditions would be unnecessary and absurd.

The value of a public water supply as a protection against fire can be approximately estimated in dollars and cents.

A properly planned system of water-works includes the provision of fire-hydrants every few hundred feet, and a sufficient force of water at each hydrant to furnish therefrom two heavy streams of water. As these hydrants are usually not farther apart than five or six hundred feet, every house owner has practically a fire-engine at his door with steam up and ready to throw two streams of water on his house at a moment's notice, day or night. The effect of such a complete protection on all combustible property can be measured in the decrease of insurance rates and the increased value of such property. To provide and maintain equally efficient protection in each individual case would entail an expense

which only rich and prosperous corporations would be warranted in incurring. In many instances the revision of insurance rates in a village, after public water-works are constructed, has secured a reduction of fifty per cent, or enough to pay the annual interest on the cost of the enterprise.

The minor protection against fire afforded each water-taker in the shape of a hand-sprinkling hose is worth many times what it costs, as it affords local means for extinguishing such fires as may originate from accident or carelessness in the house.

In providing a public water supply competent for all the varied purposes to which it is to be applied, the following requirements must be understood and fulfilled: —

First, the water furnished must be of a quality adapted to the extreme requirements of a high standard of purity. It must be free from all elements injurious or obnoxious as originally obtained, or liable to undergo deterioration after being drawn, and must be soft and colorless. Further, it must contain no mechanically dissolved sediment.

Second, it must be sufficient and constant in quantity.

To determine whether a certain water possesses the first of these qualifications, it must be chemically examined, and the delicate tests of the laboratory applied, and the precise source from which it is taken, the manner and method used in obtaining it, the neighborhood surroundings, together with the present and prospective condition of the drainage area above it, must be examined.

A final determination as to the present and prospective quality of any particular water can only be arrived at after a careful consideration of all these conditions.

The requirements as to quantity will be referred to farther on.

There are but three principal and distinct sources from which a water supply sufficient and suitable for public uses can be obtained. They are, —

1. Natural ponds or stored bodies of water.

2. Running streams, as rivers, brooks, etc.

3. Springs and sub-surface supplies.

Natural ponds and running streams are in most cases strictly surface supplies; that is, they are not only fed by and through surface channels which collect the rainfall and conduct it to lower levels, but they are affected by surface influences. In midsummer, pond and river waters become heated, often rising to a temperature of 80+° F.; in the winter they cool nearly or quite to the freezing-point.

This range in temperature very naturally produces a variation in quality, which is noticeably seen in average pond waters.

While the storing of surface water in large natural pond basins tends to, and undoubtedly does, improve its quality in many respects, still it does not secure a stable condition of the water as regards those special qualities which most affect its desirability for a public water supply. It is believed, by many of the best authorities engaged in the study of public water supplies, that to the extreme ranges of temperature through which surface waters pass during the year are largely due the variations in taste, smell, and color of these waters.

Another result of investigation in this direction is the belief that the quality of any considerable body of water depends almost wholly upon its temperature; assuming, of course, in the first place, that the water contains no specially impure elements or contributions from foreign sources.

Further, it is believed that if a temperature never rising above 60° F. could be continually maintained in any stored body of water, or in the water running in any stream, there would seldom if ever appear the swampy, fishy, or cucumber tastes which so frequently affect water supplies gathered largely or wholly from the surface.

Sub-surface supplies vary greatly in their general conditions from those collected in surface channels and basins.

While all subsoil water is primarily derived from the rain-

fall, it has, in passing down from the surface, parted with many of its surface qualities, and has become removed from the influences we have just been considering.

Instead of being subject to variations in temperature, underground waters preserve a remarkable constancy in this respect. The effect of the sun's rays in summer, and the extreme cold of winter, rarely penetrate the ground to a greater depth than seven or eight feet; and water taken from the soil at a depth of, say, twenty feet, varies but two or three degrees in temperature the year round.

Accordingly, if the water drawn from such a source absorbs no injurious elements or germs of disease as it falls upon or passes through the ground, and if the soil which it saturates, and through which it flows to the point of withdrawal, contains no undesirable impregnations or mineral elements which would affect its purity, the result will be a quality which would not only be desirable, but far superior to any surface supply.

These facts, now accepted and well understood, have created a very general preference for a subterranean supply of water where the examinations and tests show the native qualities of the water to be suitable for public use.

Such supplies are available, however, for towns and cities of small size only, owing to the rather limited amount of water to be obtained from the subsoil.

Occasionally, however, the conditions are so favorable, that a supply of several million gallons of water per day can be obtained, as, for instance, in the case of the city of Brooklyn, N.Y.

The quantity of water which will be consumed in a village like Millbury can be stated with some precision after a comparison of the population, buildings, manufactories, etc., with those of other towns supplied with water.

The surveys made for this report cover all those portions of the main village and Bramanville which in any event would require hydrant protection and street mains.

A special census of this territory has been made, and the results I find to be as follows. They are: —

396 buildings used as dwellings, accommodating 541 families;

37 buildings used for business purposes,

16 buildings used for manufacturing; and

11 buildings used for public purposes, such as schoolhouses, town-hall, churches, etc.

Population, about 3,000.

The quantity of water required to supply this territory with its present population will not be far from one hundred and fifty thousand (150,000) gallons per day; with twice the present population, three hundred thousand (300,000) gallons per day; with three times the present population, five hundred thousand (500,000) gallons per day.

If these amounts seem large to your citizens, it should be remembered that they are based on the records of other towns.

If it should be urged that the provision of so large a quantity of water daily as half a million gallons would be unnecessary, it may be explained that the records of growth of many towns having modern water supplies are so remarkable as to render it unsafe to neglect to provide for such growth in the original plan.

The importance of recognizing and providing for an increased consumption of water in the case of Millbury will be understood when it is seen that an increase of capacity after original works are built would be much more expensive than an increase of diameters and dimensions in the outset.

An average daily supply of not less than five hundred thousand (500,000) gallons is the requirement which I have adopted in this case, and consideration must at the same time be given to the opportunities for increasing this amount without unreasonable expense in the future.

To furnish an effective hydrant service, there must be a pressure in the street mains equivalent to a head of at least one hundred and fifty (150) feet.

The delivering capacity of the street mains should be equal to furnishing not less than six powerful hydrant-streams, thrown simultaneously to the full height due to the standing pressure in the pipes.

These several requirements govern the details of the plans presented in this report.

The following sources of supply have been investigated, as probably offering practicable opportunities for introduction : —

1. Singletary Pond and its watershed.
2. Ramshorn Pond and Brook.
3. The Hull Brook, in the northerly part of the town.
4. The Garfield Pond, near the Old Common.
5. The Hathaway Brook, in the southerly part of the town.
6. Springs east of the Lovell place, in the southerly part of the town.
7. The springs adjoining the Millbury branch of the Boston and Albany Railroad, and near the old Worcester Road.
8. The watershed above these springs, including the Lincoln Meadow and adjoining watershed.
9. Dority Pond.
10. Supply from the city of Worcester.

Singletary Pond has a water surface, as shown by different surveys, of from 334 to 375 acres.

The watershed, including the area of the pond itself, is 2,562 acres, or four (4) square miles. Its outflow is controlled by manufacturing corporations, and, owing to its elevated position, it is of considerable value for power.

Elevation of low water in this pond is 543.9 feet above mean high tide, and 135.4 feet above Post-office Square in Millbury.

The quality of the water in this pond is similar to that of other natural ponds in the State. The analysis shows it to closely resemble that of the well-known Spot Pond, which

supplies the city of Malden and the towns of Melrose and Medford.

It is, no doubt, subject to the extremes of temperature mentioned in this report as affecting and influencing the quality of a water at various times; and these extremes are aggravated and rendered more noticeable in this case by the continually varying level of the surface, occasioned by the drawing-down and filling-up process practised in its use as a source of mill-power.

Singletary Pond abounds in fish, and contains an abundance of the aqueous growths common to such water. A supply taken from this source, without efficient filtration and a lowering of its temperature, would not be of a permanently satisfactory character.

By assuming the entire control of the outflow of this pond, and, instead of drawing down the pond surface at any and all seasons of the year, as is now done, maintaining a uniform high-water level, the variations in quality of the water which undoubtedly now succeed each other would be very greatly reduced.

This, of course, could only be done by acquiring the sole ownership of the pond, or at least an absolute ownership of the outlet to an extent which would vest the town with the right to maintain a constant level therein at any or all times, as it should see fit.

As the acquiring and exercising of this right would take from the mill-owners below all advantage of the pond as a storage-basin, it would naturally be an expensive purchase.

On the other hand, the supply required to furnish the town for all purposes could be taken from a level a few feet below the extreme low-water plane of the pond as now established, and such means as are known to be efficient applied for the filtration of the water thus taken.

Under such an arrangement, the use of the pond basin for storage purposes would remain unimpaired, and the injury

to mill-owners below, if measurable, would be confined to the value of the precise amount of water withdrawn.

Singletary Pond, owing to its magnitude, convenient location, and superior elevation, very naturally suggests itself as an appropriate, suitable, and competent source of supply for Millbury. Believing this to be the case, I have specially studied the opportunities for utilizing this pond, and will refer to them more in detail farther on.

Ramshorn Pond is a large body of water stored and used for mill-purposes. Its outlet is Ramshorn Brook, flowing through West Millbury, Pondville, Auburn, and New Worcester, to South Worcester, between which point and Quinsigamond it joins Mill Brook, the two forming the Blackstone River.

This pond varies in its water level something over twenty (20) feet, and the quality of its water is much inferior to that of Singletary.

I do not consider Ramshorn Pond as in any way suitable, or capable of being made suitable at any practicable expense, for the purposes of Millbury.

Ramshorn Brook at one point in its course, viz., in the valley west of the Old Common, might be utilized, provided sources of pollution above that point were removed.

It is probable that a supply of ground-water could be obtained by proper excavations in the comparatively flat meadow areas adjoining this point, and replenished or re-enforced by water of the brook in extremely dry weather. As there are better opportunities than this, however, I have not attempted to develop the details of such a plan, but will leave this possible source for brief reference again, farther on.

The Hull Brook, in the northerly part of the town, is so situated that it is hardly worth consideration for our purposes. It is too remote to be of any value, and its water-shed is distinctly separated from the territory to be supplied with water, by a continuous, rough, and highly elevated section of territory.

There are no good opportunities for storing the water along the line of this brook; and, if there were, the quality of the water would condemn it for our purposes.

The Garfield Pond, so called, lying in the little valley east of the Old Common, has been mentioned as a desirable source, and one likely to furnish water of superior quality. I understand this source was mentioned and proposed by the projectors of a private company who had in view the supplying of the town of Millbury with water.

The pond covers an area of about 3 acres, the average depth of water is about 3 feet, and its watershed is less than 60 acres. Its present water surface is very nearly 583 feet above the reference plane, 40 feet above low water in Singletary Pond, and about 175 feet above Post-office Square. It is of no use to attempt to increase the storage capacity of this source, were there opportunities to do so, as the greatest possible supply obtainable is far below the most modest requirement in the case. There are no chances to create storage-basins below on the brook flowing from the pond.

By raising the pond level itself, and cleaning out the basin, quite a little distributing reservoir might be made; and by pumping a supply of ground-water from the low lands near the Ramshorn Brook, as mentioned before, the combination might be made to furnish a sufficiency of water at a proper elevation. I do not consider this a practicable plan, and certainly not a desirable one to adopt except in the absence of any thing better.

The Hathaway Brook, emptying into the Blackstone River below Simpson's factory, has its origin in the town of Sutton, passes through the shallow pond on the farm of Harry M. Goddard, thence falls rapidly in its course to the river.

The pond on the Goddard farm is a small body of dark-colored water, wholly unfit for public or private use. A possible high-water level in this pond would have an elevation of 498 feet above mean high tide, or 90 feet above Post-

office Square. The area of the pond at this level will be about eight (8) acres, and the depth of water between 7 and 8 feet.

As this source is in no way adapted to the requirements of Millbury, it can be dismissed from further consideration.

The springs east of Burbank Hill and near the Lovell place were examined, and found to be wholly incompetent for our purposes. Nor does it appear that they can be utilized in connection with any other source as a part supply.

The territory north and east of the main village lying between the Blackstone River and Dority Pond was carefully examined and surveyed.

Beginning near the Worcester line, the upper part of this territory consists of a flat watershed covered with a thick growth of underbrush and wood, except that open portion of it called the Lincoln Meadow.

At the lower end of this meadow the water is partly held back by a small dam.

The bed of the brook just below this dam is about 505 feet above mean high tide and 97 feet above Post-office Square.

Passing down the valley from this point, the brook falls rapidly for a distance of about half a mile, when it apparently divides: the main brook continuing to fall rapidly as it flows in a southerly direction to the culvert under the Boston and Albany Branch Railroad, through which it passes into the small springy basin on the southerly side of the track, and thence into the Dority Brook.

The small stream of water which appears to leave this main brook at the point of division mentioned, flows southwesterly into the Blackstone River. Just below the point referred to, there is a location for a low dam which would hold back perhaps one million (1,000,000) gallons of water. It is not a favorable opportunity, however, and hardly worth the outlay which would be required to utilize it.

The only point in this territory which seems to offer any

inducement for our purpose is the spring basin near the railroad, before referred to.

The level of standing water in this basin is 373.6 feet above mean high tide, 20 feet below the level of high water in Dority Pond, 11.6 feet above the high-water level of the Cordis Mill's well, and 35 feet below Post-office Square.

The contours and levels of the territory above this spring basin, together with the surface indications of the vicinity, are such as to suggest the practicability of obtaining a sufficient supply of suitable ground-water at this point.

The success of Mr. Gegenheimer in obtaining a large supply of water of this kind by means of the inexpensive well constructed a little farther to the westward, and near the railroad, is an indication of considerable value in this direction.

To ascertain approximately the nature of the soil in regard to quality and permeability, or, in other words, its freedom from objectionable elements which might operate to injure the water for general use, and its capacity to permit the free passage of water into an excavation made for the purpose, a test-well was sunk to the depth of thirty-three (33) feet, and samples of the soil obtained at different depths.

By means of this well, a sample of apparently pure subsoil water was obtained, and sent to the State Board of Health for analysis and examination.

The results of this examination are shown in the table appended hereto, and prove the water to be well adapted to the requirements of a public water supply for Millbury.

A sample of the water flowing in the brook draining the spring basin, together with one taken from Singletary Pond, was analyzed at the same time, and the results will be found in the table.

After this test-well had been thoroughly pumped out, and all sediment removed, the water continued to flow, and is now flowing at the rate of very nearly two gallons per minute.

While this is of approximate value only, it indicates that

there is a head or pressure standing on the water in the soil at the level of the bottom of this driven well sufficient to discharge it at a level considerably above the surface of the ground.

In such a case as this, if it can be shown that a sufficiently large watershed exists above the point where it is proposed to take the supply, and that the soil on the surface of this watershed, and to a considerable depth, — say, of thirty or forty (30 or 40) feet, — consists of porous and absorbent material, it will be safe to depend upon obtaining a comparatively large and regular amount of water by means of deep excavations or driven pipes.

There is an element of uncertainty in the use of driven pipes in such cases, owing to their limited power to collect water, and their liability to slowly fill up with an accumulation of the finer parts of the soil.

In the case of this particular spring basin, many of the conditions necessary to a reasonably large supply of water are present.

I believe that a circular well thirty (30) feet deep by thirty (30) feet in diameter, sunk in or very near this basin, would yield a continuous supply of at least 25,000 gallons of water per hour.

This source has much to recommend it in the matter of location as regards convenience, removal from present and future polluting influences, and the opportunity to supplement or re-enforce its capacity from other sources.

Dority Pond, both naturally and in its present condition, is but poorly adapted to the requirements as to quality for a public water supply.

The report of Benjamin Wright, engineer of the old Blackstone Canal, gives an estimate of the maximum holding capacity of Dority Pond as about four hundred and fifty million (450,000,000) gallons; but so much shallow flowage would exist in this pond, even at its high-water level, that it would be impossible to secure and maintain therein that low degree

of temperature required to secure a palatable and clean water.

Notwithstanding these objections to this pond as a source of supply, it would be practicable to filter and purify enough water from this source to supplement a supply from the spring basin just described, should the latter be adopted, and after a number of years prove insufficient to meet the requirements of the largely increased growth of the town of Millbury, which we must provide for at this time. Water can be brought by gravity from Dority Pond to the spring basin.

So we may consider it practicable to use Dority Pond in this way, so far as the quality of the water is concerned.

It is evident that Dority Pond is of considerable value for furnishing power for manufacturing purposes, and that the acquiring of the absolute control of this pond, and the holding back of its water for the purpose of maintaining a constant high-water level, would involve a large expense to the town.

There is another opportunity to re-enforce the supply from this spring basin at a comparatively small expense, although it cannot be said that it would be a desirable opportunity; that is, by damming the Lincoln Meadow, and holding back as much water as possible, and conducting it by a suitable pipe line down to the proposed well.

The cost of a dam at the Lincoln Meadow, with gatehouse and screens, would not exceed $5,500. The cost of a proper pipe line from such dam down to the Boston and Albany Railroad would be about $14,000; the average daily quantity of water which the watershed above such dam would probably furnish would not exceed 200,000 gallons per day.

There is yet another source from which Millbury may be supplied, and that is the Worcester Water Works. So far as the practicability of such a supply is concerned, the following facts can be given: —

1. The Worcester Works consist of two distinct services,

— quite a portion of the higher levels of the city, and the principal business sections, where a heavy pressure is of value for mechanical purposes, being supplied under a head due to a reservoir elevation of 828 feet above mean high tide; the other portions of the city being supplied from what is called the Holden system, under a low service pressure due to an elevation of 170 feet less, or 658 feet above mean high tide.

2. One of the principal mains of the high service supplied from the Lynde-brook reservoir extends to Quinsigamond Village, where the elevation of the highway south of the bridge over the Blackstone River, near the Washburn and Moen Wire Works, is 440 feet above mean high tide, or 36 feet above Post-office Square, Millbury.

The size of this pipe supplying Quinsigamond Village is ten inches, and it appears to be the only part of the Worcester system of piping which can be extended to Millbury.

In a recent interview with City Engineer Allen, he expressed the opinion that a connection with the Worcester system for the purpose of supplying Millbury would of necessity have to be made at this point.

3. The distance from the end of this ten-inch main, as now laid, to the Millbury town line, is 9,800 feet; from the town line to the junction of North Main Street and the Park Hill Road, 8,000 feet; from this last point to Post-office Square, Millbury, 3,300 feet: making the total distance from the end of the ten-inch main at Quinsigamond Village to Post-office Square, Millbury, 21,100 feet, or 4 miles.

The static pressure in Post-office Square, Millbury, from the high service of Worcester, would be, provided there were no draughts of water from the high-service piping, 182 pounds per square inch, — a pressure much too great to attempt to control in any ordinary system of piping.

While it is hardly probable that this pressure would ever be reached in Millbury, owing to the continual use of water in Worcester, it would not, in my opinion, be advisable to introduce a supply from this source, except through the

medium of a distributing reservoir arranged to receive its supply automatically from the Worcester high service, and containing at least enough water to supply Millbury two or three days. By such an arrangement all variations of pressure in the supply main extended from Quinsigamond Village would be equalized in the reservoir, and the pressure on the system of piping in Millbury would be practically constant and uniform.

As to how this plan can best be carried out as regards its engineering features, we can see by considering the following details, which to a certain extent must be adopted in any plan for providing the main village and Bramanville with a competent water service : —

As it is intended to supply the higher levels of Bramanville with a reasonable fire protection, a reservoir level of not less than six hundred (600) feet above mean high tide must be provided.

None of the high lands around Millbury Village are high enough for that purpose.

Burbank Hill appears to be not only well adapted to the purpose, but the only site sufficiently elevated. Its location in reference to the general plan of piping required for the two villages is all right, and it presents no unusual difficulty to reservoir construction.

I have selected the lot of land belonging to William F. Lovell, containing about four acres, as a desirable and convenient site, and the surveys show a practicable high-water level for a reservoir on this lot to be 636 feet above our reference plane ; 224 feet above Post-office Square ; 92 feet above low water in Singletary Pond ; 93 feet above the threshold of main entrance to Wheeler's mill, Bramanville ; 52 feet above the underpinning of Samuel Maxwell's house, Bramanville ; 165 feet above Highland Hall, on Prospect Avenue ; 262 feet above the spring basin near the Boston and Albany Branch Railroad ; 192 feet below the Worcester high service ; and 22 feet below the Worcester low service.

Other differences of level you will find in the table of levels following this report.

The main pipe to connect this reservoir with the main village should be twelve (12) inches in diameter, and the capacity of such main pipe will be equal to furnishing not less than ten (10) heavy fire streams thrown simultaneously on the main and adjoining streets.

The system of distributing pipes, stop-gates, and fire hydrants is shown on the plan submitted herewith, together with all data and memoranda necessary to make this plan self-explanatory.

The two plans which I consider practicable are the following: —

The first, which I will call the Local Pumping Plan, will be as follows: The initial source of supply is to be the spring basin near the Branch Railroad, and the water is to be obtained from this source through the medium of a deep collecting well. Near this well a pumping station is to be located, and water is to be forced, by means of appropriate machinery, through a twelve-inch force-main laid through the old Worcester Road, Riverlin and Canal Streets, into a general system of distributing pipes, to be laid through the streets of the main village.

Such water as is not used in these distributing pipes is to be forced on through the twelve-inch main to be laid through Elm Street to Bramanville, thence through Burbank Street to the proposed reservoir on Burbank Hill. The westerly part of Bramanville is to be supplied from a ten-inch main laid in continuation of the twelve-inch from Burbank Square to Wheeler's cotton mill.

The capacity of the reservoir proposed for this plan, as shown on the map, is to be about 1,000,000 gallons, or enough to supply the present population one week.

When it becomes necessary to supplement the supply of the source proposed in this plan, the quantity required can easily be taken from Singletary Pond by gravity.

The way to do this is shown in detail on the map submitted, and may be described as follows: A secondary main is to be laid from Burbank Square, by way of the main street, to and into Singletary Pond, the entrance into the pond to be made below the bottom of the present outlet. By a simple arrangement of automatic valves, to be located in the piping in Burbank Square, the supply from Singletary Pond can be furnished intermittently, and only when required to supplement the capacity of the well at the pumping station.

By the operation of these valves the higher level of Bramanville would at all times have full reservoir pressure; the entire system of piping in both villages would have full reservoir pressure when water was being pumped from the primary source, while at other times the main village would be supplied in part from Singletary Pond. By the opening of one valve in Burbank Square, the full reservoir pressure could be admitted to all sections of the piping, if required, as in case of an extensive fire in the main village.

It is not probable that a supplementary supply from Singletary Pond would be required for several years, but I regard this method of re-enforcing the primary supply as preferable to storing water on the Lincoln Meadow or drawing from Dority Pond.

I have considered the feasibility of obtaining a supply solely from Singletary Pond. With the object of avoiding the variable qualities which the water undoubtedly contains, a very careful examination of the shores of the pond was made, with a view to finding a suitable location for a filter gallery.

There appears to be no desirable opportunity of this kind. An attempt was made to sink a tube well on the westerly side of the pond near the West Millbury Road; but, after four attempts, the work was given up, nothing but ledge rock and bowlders being found at a depth of from eight to thirteen feet.

Similar tests were made near the outlet of the pond in the

Harris Meadow with similar results, the ledge being very hard, and no water being obtained. An examination of the watershed surrounding Singletary Pond was made with a view to finding some opportunity for storing water at a higher level than that of the pond itself. But one location was found, and the quantity of water it could be made to furnish is too small to warrant the necessary outlay. The particular location I refer to is the small meadow basin and watershed on the west shore of the pond near the DeWitt place. The stream, I believe, is called the Fitz Brook; and the elevation of the meadow basin is about 610 feet above our reference plane, or 68 feet above Singletary Pond. This would make it about 25 feet below proposed reservoir on Burbank Hill. There are two or three springs of clear water in the territory above this meadow, but they are large enough for the use of two or three families only. The ravines and watershed west of Burbank Hill are of no value for our purpose, there being neither water enough, nor opportunity to store what there is.

In view of all these facts, I think we must conclude that Singletary Pond itself must be to a very considerable extent the source of the future water supply of Millbury; or, if this pond is not to be utilized either for the whole or a part of the public water supply of the town, then recourse to the Worcester Water Works appears to be the only alternative. In this latter event the distributing reservoir should be located on Burbank Hill, as already described; its capacity should be doubled (the gravity main to Singletary Pond would, of course, be unnecessary), and connection should be made with the Worcester system through a twelve-inch main, to be laid from Post-office Square (where it would connect with the twelve-inch main leading to the reservoir) to Quinsigamond Village. By means of such a connection, water could be delivered into the Burbank Hill reservoir at a rate of at least 50,000 gallons per hour.

A check-valve could be placed in this supply main just

beyond the Park Hill Road, to prevent the back flow of water from the Millbury pipes in case of a rupture in the great length of main between that point and Quinsigamond Village. On the Worcester side of this check-valve there should be placed another valve, for reducing and controlling the pressure; and this valve could be so adjusted, after a little experience, as to allow the daily amount required in Millbury to pass, and no more.

To summarize, then, we have first a plan by which water will be taken from a well near the railroad, and pumped by steam through the village to Burbank Hill, and into a reservoir. When the supply from this well becomes insufficient in quantity, it is to be supplemented by laying a gravity main to Singletary Pond, thereby introducing an automatic low service pressure for the main village. This plan will be mechanically successful, will furnish excellent water, and can be maintained and operated without unusual expense.

Second, we have a plan by which the town of Millbury can lay its own pipes, build a suitable receiving and distributing reservoir on Burbank Hill, and purchase the water required of the city of Worcester, the same to be delivered with the aid of proper safeguards and appliances, and guaranteed in its permanence by the Worcester authorities.

In the first case, the town will have to meet the cost of construction, the interest on the outlay, and the cost of pumping the water.

The cost of construction will, of course, include the expense of securing such water rights as are necessary, but claims for such rights cannot be presented until the supplementary supply from Singletary Pond is taken. No water rights could be measurably affected by taking a supply of ground-water from the vicinity of the spring basin near the railroad, as proposed.

In the second case, the town will have to meet the cost of construction, the interest on the same, and pay to the city of Worcester whatever price may be agreed upon for the water furnished.

Until it is known what value would be placed by the Worcester authorities upon the water to be thus furnished, a final comparison of the respective costs of the two plans cannot be made; but it seems to me there are elements of advantage to both parties in this case, which are worthy of very careful consideration.

The quality of the Worcester high service supply is very good, and in many ways superior to that of the water in Singletary Pond. By adopting it, the town of Millbury would be saved the cost of construction of an independent pumping plant, and the perpetual cost of operating the same; while it would possess a capacity and power equal to that to be furnished by what I have termed the "Local Pumping Plan."

By such an arrangement, the city of Worcester would receive an income from the sale of a quantity of water which it can no doubt spare from its now very complete system of water-works, and the furnishing of which by the method described would in no way impair the efficiency of its high service distribution piping.

A reduction of the pressure at Quinsigamond Village by draughts from the high service distribution piping in Worcester, amounting to a loss of head of one hundred and twenty (120) feet, could be made, and there would then remain at the former point a pressure sufficient to force into the Burbank Hill reservoir, through the twelve-inch main described, an hourly supply of 50,000 gallons of water.

But at no time would it be necessary to draw water from the Worcester piping at such a rate; on the contrary, only enough to supply the actual consumption in Millbury would be called for: and, as the result of the averaging effect of the proposed reservoir on Burbank Hill, the furnishing of this amount would be distributed over twenty-four hours.

If the daily consumption in Millbury should be 150,000 gallons, then the hourly draught from Worcester would be 6,250 gallons, or at the rate of a little more than 100 gallons per minute.

The effect of such draught on the Worcester high service would hardly be measurable in the reduction of pressure resulting.

We will now consider the cost of construction, cost of maintenance, and probable revenue of the two plans.

For the Local Pumping Plan there will be required about $9\frac{1}{2}$ miles of piping, 95 stop-gates, and 78 fire hydrants, the cost of which, all laid complete and ready for use, will not exceed	$74,280 91
And this includes an additional allowance for rock excavation of $10,000.	
The pumping station, including machinery and foundations, should not exceed . . .	11,400 00
The collecting well can be constructed for .	8,000 00
The reservoir on Burbank Hill for . . .	9,500 00
Making a total of	$103,180 91
There should be added to this 300 service pipes at $15	4,500 00
	$107,680 91
Add for contingencies, engineering, and land damages five per cent	5,384 05
Total cost	$113,064 96

The cost of operating this plan, allowing a daily consumption of 200,000 gallons of water, will be, —

For engineer's salary	$1,000 00
120 tons of coal at $6	720 00
Oil, waste, and repairs	200 00
	$1,920 00
Allow for superintendence, collecting water-rates, and office expenses	1,000 00
Making annual cost of operating .	$2,920 00

Amount brought forward . . .	$2,920 00
To this amount there must be added the interest on the cost of construction, which will be four per cent on $113,064.96 . . .	4,522 60
And an annual instalment on the debt, to meet the same when the loan becomes due .	2,500 00
Making the total annual cost . .	$9,942 60

The cost of construction of the Worcester Plan will be about as follows: —

Thirteen miles of piping, stop-gates, automatic valves, and 80 fire hydrants, including an allowance of $15,000 for rock excavation, will not exceed	$108,792 30
Add 2 000,000-gallon reservoir on Burbank Hill,	16,000 00
Service pipes, as before	4,500 00
	$129,292 30
Add, as before, five per cent	6,424 62
	$135,716 92
Of this amount the city of Worcester should pay for pipe laid in its territory . .	21,476 18
Leaving net cost	$114,240 74

The cost of operating this plan will be made up solely of superintendence, collections, and office expenses	$1,000 00
Add four per cent annual interest on cost of construction	4,569 63
Also an annual instalment on the loan . .	2,500 00
	$8,069 63

Annual cost Local Pumping Plan	$9,942 60
Annual cost Worcester Plan	8,069 63
Difference	$1,871 97

which at four per cent represents a capital of $46,799.25.

It will be observed that the estimate of the cost of construction of the Local Pumping Plan does not include the cost of the supplementary gravity main from Singletary Pond to Burbank Square. The length of this main will be about 4,900 feet, and its cost, including the grade cut, rock excavation, and inlet work, consisting of a submerged crib with adjustable screens, will not exceed, I think, $24,735. Although the incurring of this expense would not become necessary until the growth of the town had increased the valuation so largely as to make such increase in the water debt no burden, in carrying our comparison farther we

should add this amount	$24,735 00
to the cost of the Local Pumping Plan as given,	113,064 96
Making a total of	$137,799 96

Something must be allowed and added to this amount for the injury to mill-rights below the pond.

While I do not believe this item will be an excessive one, I think it should be recognized as an undoubted element of cost, to be properly charged to construction.

It may be inquired why I have not proposed taking the whole supply from Singletary Pond, if that body of water is to be utilized in any way for our purpose.

By so doing, the cost of the graded conduit would be saved, as the water could be taken by suction at a pumping station located near the pond, and pumped thence into a reservoir on Burbank Hill, with an expenditure of less power than would be required in the plan proposed.

The reasons for not utilizing Singletary Pond as the sole source of supply for Millbury, which appear to me to be sufficient in view of all the facts in the case, are these: —

1. Without an absolute control of the outlet and the maintaining of a full pond at all times, the quality of the water would occasionally be subject to disagreeable tastes and smells.

2. To obtain and exercise such absolute control would involve an expense much greater, in my opinion, than the town would be justified in incurring.

3. It would probably be practicable to purify by filtration such water as might be drawn from the pond by the pumping station just referred to; but the cost of a competent filter, adapted to perform its work under the varying water levels in the pond, would be quite an item in itself. There are objections to the adoption of purely artificial methods of filtration, although the mechanical construction and operation of some of the patented devices — as the Hyatt and National filters, for instance — are ingenious, and, under some circumstances, remarkably efficient.

4. The quality of the ground-water to be obtained by the plan proposed will be much superior to any natural pond water, while the quantity to be obtained by the method described will be more than enough to justify the expense required to utilize it.

5. This quantity of water will be sufficient for the various uses of the town until the population is doubled, thus postponing the expense of utilizing Singletary Pond for several years.

One of the primary considerations entering into the project of a public water supply is that of net annual cost.

I have given fully, and without reservation or allowance, the gross annual cost to the town, including the instalment on the principal of the debt incurred, necessary to entirely extinguish the latter at maturity.

In other words, the figures I have given provide for paying up the whole cost of construction year by year, so that at the end of the period of the loan the town will own its own water-works free of debt, and can thereafter apply the

income of the water department to the reduction of general taxation, or it can greatly reduce the cost of water to consumers.

Now, it is proper that an estimate of the revenue which will be collected from the sale of water should be made, and deducted from the figures of gross annual cost given.

Of the 541 families found by census on the proposed pipe lines, 400 at least will take water. These families will

average $10	$4,000 00
It is safe to count upon 50 private stables at $10,	500 00
Also 100 private hand hose at $5	500 00
Livery and boarding stables	200 00
Buildings used for business purposes . . .	300 00
Manufacturing establishments, for steam, etc. .	500 00
Public buildings, schoolhouses, churches, etc. .	300 00
	$6,300 00

After deducting this income from the gross annual cost of $9,942.60, there remains a deficiency of $3,640.60. If put into the annual assessment, this would increase the rate of taxation $1.82. A citizen owning property valued by the assessors at $1,000 would have his tax bill increased $1.82; if his property was valued at $2,000, his tax would be increased $3.64.

But such slight increase of taxation would not be without its equivalent benefit. The thorough and modern system of fire protection certainly must be allowed to have a practical value. No movable fire department, even when made up of the best apparatus, can compare with such a hydrant service as either of the plans described in this report would furnish.

Accordingly, a large pecuniary value is voluntarily placed upon competent water-works on this score alone, and many towns and villages have introduced public water supplies mainly for the safeguards they would furnish to the private, manufacturing, and business interests of their citizens.

If in this case we follow the example of many other towns by placing a fair value — say, in the form of an annual rental of $40 — upon each hydrant furnished by the plan proposed, we shall very nearly provide for this deficiency of $3,640.60.

After water is introduced, the revenue from water-takers will so increase year by year that the amount of this annual appropriation for a hydrant service can be gradually decreased, and there are a number of instances where the revenue equals or exceeds all necessary annual expenditures.

There is no better and more practical evidence of the value of a public water supply in regard to pecuniary returns than the willingness of many investors to put capital into private water companies.

Many towns in New England have, without proper deliberation, placed themselves under contract to appropriate and pay over annually to such private companies, for a term of years, a sum of money equal to or in excess of the deficiency which would have existed in the account, had they introduced public water supplies. And in many of these cases the contracting towns not only have bound themselves to pay high market rates, but have exercised no supervision over the work of construction, nor entered into any express stipulation as to the capacity and quality of the water-works constructed. The result in many instances has been the construction of cheap plants, designed without regard to the special requirements of the case, and established and operated with the sole object of paying dividends.

One objection to the surrendering of the franchise of the territory by a town to a private water company is the absence of any ownership resulting therefrom in a project which concerns the domestic convenience, health, and safety of every property-owner.

Pure water is a necessity, but should never be permitted to become a luxury by the enforced payment of high prices for it.

When, because of the inability to secure public action

authorizing the introduction of a public water supply, an association of citizens undertakes the work of providing the advantages and safeguards of such a supply, the enterprise should receive the approval, co-operation, and contributions of all property-owners.

But I think, on the other hand, that where a surrender of the franchise is made to construction syndicates who will use the opportunity for purposes of speculation, a great folly is unwittingly committed, which necessarily must be perpetuated by increasing annual appropriations for the service performed, or revoked by a purchase of the privileges granted and the works constructed, all at an inflated price, to be raised, at least in part, by an increased rate of taxation.

In contrast to this is the more satisfactory way of assuming public ownership in the outset, paying for the works by a long-term loan, and eventually owning them free of debt, with every taxpayer and property-owner a stockholder.

Yours respectfully,

PERCY M. BLAKE,
Civil Engineer.

HYDE PARK, MASS., Jan. 28, 1888.

COMMONWEALTH OF MASSACHUSETTS. — STATE BOARD OF HEALTH.

WATER ANALYSIS. — (Parts in 100,000.)

MILLBURY, MASS., December, 1887.

No.	Date of		Appearance.		Odor.		Residue on Evaporation.				Ammonia.		Chlorine.	Nitrogen as Nitrites and Nitrates.	Nitrites.	Hardness.		Remarks.
	Collection.	Examination.	Turbidity.	Color.	Cold.	Hot.	Total.	Loss on Ignition.	Fixed.	Odor on Ignition.	Free.	Albuminoid.						
	Dec.	Dec.																
1,375	10	12	Very slight; very little flocky sediment.	0.0	Faintly mouldy	Very faintly musty.	3.05	0.25	2.80	Faint, peculiar.	.0000	.0030	.18	.035	None.	0.9	1.	Spring basin near Albany Branch Railroad.
1,376	10	12	Distinct; some whitish flocky sediment.	0.15	Very faintly straw-like.	Distinctly grassy and somewhat disagr'able.	2.95	0.95	2.00	Peaty.	.0011	.0209	.20	.000	None.	0.8	3.	Singletary Pond.
1,377	10	12	Slight; very little light flocky sediment.	0.0	Very faintly mouldy.	None.	3.30	0.50	2.80	Faintly acid.	.0000	.0012	.21	.040	None.	0.8	2.	Driven well at spring basin.

MILLBURY WATER WORKS.

Schedule of Piping.

Street.	From—	To—	12-inch.	10-inch.	8-inch.	6-inch.	4-inch.	Pounds per foot.
North Main	Post-office Square	North Miles	–	1,770	–	–	–	65
" "	North Miles	Park Hill Road	–	–	1,507	–	–	45
South Main	Post-office Square	Sylvester Stockwell's	–	–	2,821	–	–	45
Elm	" "	Canal Street	–	1,100	–	–	–	70
"	" "	Main Street, Bramanville	2,100	–	–	–	–	85
"	Main, Bramanville	Henry Carter's	–	–	–	1,798	–	30
Canal	Rivelin Street	Elm Street	1,457	–	–	–	–	92
"	Elm Street	North Main Street	–	–	1,195	–	–	50
Riverlin	Canal Street	Old Worcester Road	1,300	–	–	–	–	92
Old Worcester Road,	Rivelin Street	Pumping Station	1,900	–	–	–	–	92
Miles	North Main Street	North Main Street	–	–	–	1,547	–	30
New street	" " "	Charles Gould's	–	–	–	368	–	30
Park Hill Road	" " "	John Martin's	–	–	–	824	–	30
Worcester Road	" " "	William Burns's	–	–	–	649	–	30
West	" " "	Waters Street	–	–	–	968	–	30
Summer	" " "	Cherry Street	–	–	–	–	536	20
Grove	" " "	Waters Street	–	–	–	969	–	30
Church	" " "	Canal Street	–	–	–	756	–	30
Cherry	Grove Street	West Street	–	–	–	–	817	20
Waters	Elm Street	" "	–	–	–	1,347	–	30
School	" "	South Main Street	–	–	–	625	–	30
Providence	Canal Street	Simpson's Mill	–	–	–	2,500	–	35
Maple	Providence Street	South Main Street	–	–	–	1,840	–	35
Dublin	" "	Westerly	–	–	–	–	656	24

Coral	Maple Street	Westerly	–	–	–	–	407	24
Prospect Avenue	Miles Street	Easterly	–	–	–	628	–	30
Sycamore	South Main Street	Lane	–	–	–	1,150	–	30
"	Rhodes Street	Peter McClosky's	–	–	–	1,113	–	30
Main, Bramanville	Elm Street	Burbank Square	3,275	–	–	–	–	92
" "	Burbank Square	Harris Place	–	4,040	–	–	–	65
Burbank	" "	Reservoir	1,900	–	–	–	–	85
High	" "	Main Street	–	–	–	817	–	30
"	" "	Beach Street	–	–	–	958	–	30
High-street Avenue	High Street	John Hinchliffe's	–	–	–	400	–	30
Beach	Main Street	George Neff's	–	–	–	1,370	–	30
Rhodes	" "	Flume	–	–	–	550	–	30
Gould	" "	Elm Street	–	–	–	800	–	30
Hydrant branches and blow-offs	– –	– –	–	–	–	900	–	35
			–	–	–	–	200	24
Totals			11,932	6,910	5,523	22,877	2,616	–

MILLBURY WATER WORKS.

TABLE OF LEVELS.

LOCATION OF ELEVATION.	Above mean high tide.	Below low water, Singletary Pond.	Below high water, Burbank Hill Reservoir.	Below high service, city of Worcester.
Mean high tide, Boston Harbor	000.0	543.9	636.0	828.7
Singletary Pond, low water . . .	543.9	000.0	92.1	284.8
High water in proposed new reservoir on Burbank Hill	636.0	+92.1	000.0	192.7
City of Worcester, high service . . .	828.7	284.8	192.7	000.0
Intersection of Canal and Riverlin Sts. .	352.2	191.7	283.8	476.5
" Canal and Providence Sts. .	357.8	186.1	278.2	470.9
Cordis Manufacturing Company's west tower, threshold of door	356.3	187.6	279.7	472.4
Underpinning of Tourtellott House . . .	354.1	189.8	281.9	474.6
Crest of Cordis Manufact'g Company's dam,	360.8	183.1	275.2	467.9
Intersection of Canal and Elm Sts. . .	368.4	175.6	267.6	460.3
" Canal and Church Sts. .	375.7	168.2	260.3	453.0
Upper step of main entrance to Town Hall .	409.5	134.4	226.5	419.2
Intersection of Elm and Waters Sts. . .	418.8	125.1	217.2	409.9
Threshold of main entrance to High School,	430.8	113.1	205.2	397.9
Intersection of Elm and River Sts. . .	411.6	132.3	224.4	417.1
P. & W. Railroad crossing at Elm St. . . .	398.7	145.2	237.3	430.0
Stone bound S.W. of Gowan's Bridge .	396.2	147.7	239.8	432.5
Intersection of Elm and Main Sts. (Bramanville)	394.4	149.5	241.6	434.3
Underpinning of Mrs. A. H. Waters's house,	428.8	115.1	207.2	399.9
Post-office Square	408.5	135.4	227.5	420.2
Underpinning of Baptist Church . .	419.3	124.6	216.7	409.4
Intersection of North Main and Church Sts.	414.9	129.0	221.1	413.8
" North Main and Grove Sts. .	417.8	126.1	218.2	410.9
" North Main and Canal Sts. .	419.0	124.9	217.0	409.7
" North Main and Summer Sts.	418.7	125.2	217.3	410.0
" North Main and West Sts. .	421.8	122.1	214.2	406.9
" North Main and Miles Sts. .	418.3	125.6	217.7	410.4
" North Main and new Sts. .	410.3	133.6	225.7	418.4
" North Main and Park Hill Road	408.3	135.6	227.7	420.4
Underpinning C. D. Morse's house . .	431.3	112.7	204.8	397.4
Near South Main Street Bridge over Blackstone River	385.0	158.9	251.0	443.7
Crest of Atlanta Mills dam . . .	386.2	157.8	249.8	442.5
Intersection of South Main and Maple Sts. .	395.1	148.8	240.9	433.6
Crest of Millbury Mills dam	374.1	169.8	261.9	454.6

MILLBURY WATER WORKS — *Continued.*

LOCATION OF ELEVATION.	Above mean high tide.	Below low water, Singletary Pond.	Below high water, Burbank Hill Reservoir.	Below high service, city of Worcester.
Intersection of So. Main and Sycamore Sts. .	398.8	145 1	237.2	429.9
" So. Main and Curve Sts. .	424.9	119 0	211.1	403.8
Underpinning of John Gegenheimer's house,	435.5	108 5	200 5	393.2
Intersection of So. Main St and Sutton Road,	415.7	128 2	220.3	413.0
Underpinning of Sylvester Stockwell's house,	420.9	123.1	215.1	407.8
Sycamore St. near John Hayward's . .	416.3	127.6	219.7	412.4
Sycamore St. near Lane, going southerly .	396.9	147.0	239 1	431.8
Underpinning of Peter McClosky's house .	397.0	146.9	239 0	431.7
Intersection of Maple and Coral Sts. . .	376.1	167.8	259.9	452.6
" Maple and Curve Sts. . .	379.9	164 0	256.1	448.8
" Providence and Maple Sts. .	358 0	185.9	278 0	470 7
Underpinning of Catholic Church . .	368 8	175.1	267.2	459.9
Intersection of Providence and Dublin Sts. .	357.4	186 5	278 6	471.3
" Providence and Riverlin Sts.	355.4	188 5	280 6	473.3
Crest of Peter Simpson's dam . . .	346.4	197.5	289.6	482.3
Underpinning of Peter Simpson's storehouse,	350.4	193.5	285.6	478.3
Surface of George Rice's millpond . .	356.6	187.4	279.4	472.1
Underpinning of Grammar School near Dublin St.	377.8	166.1	258.2	450.9
Underpinning of C. D. Donovan's house on Dublin St.	386.7	157.2	249.3	442.0
Intersection of Riverlin St. and old Worcester Road	363.9	180 0	272.1	464.8
Underpinning of William Connor's house .	379.2	164.7	256.8	449.5
B. and A. R.R. crossing over old Worcester Road	385 3	158.6	250 7	443.4
Intersection of Grove and River Sts. . . .	398.7	145.2	237.3	430.0
" Grove and Waters Sts. .	409.7	134.2	226.3	419.0
" Grove and Cherry Sts. .	412.7	131.2	223.3	416 0
Underpinning of the Walling House . .	424.5	119 4	211.5	404.2
Intersection of Miles St. and Prospect Ave.	430.9	113.0	205.1	397.8
Underpinning of Elbridge Farnsworth's house on Prospect Ave.	470.6	73.3	165.4	358.1
Intersection of Cherry and Summer Sts. .	407.4	136 5	228 6	421.3
" West and Cherry Sts. . .	405.1	138 8	230.9	423 6
Underpinning of French Catholic Church .	417.0	126.9	219.0	411.7
Intersection of Waters and West Sts. . .	398.7	145.2	237.3	430.0
Crest of C. D. Morse's dam . . .	396.1	147.8	239.9	432.6
Threshold of depot P. and W. Railroad .	399.6	144.3	236.4	429.1
BRAMANVILLE.				
Intersection of Main and Gould Sts. . .	417.2	126.7	218.8	411.5
" Main and Rhodes Sts. . .	443.4	100.5	192.6	385.3

MILLBURY WATER WORKS — *Concluded.*

Location of Elevation.	Above mean high tide.	Below low water, Singletary Pond.	Below high water, Burbank Hill Reservoir.	Below high service, city of Worcester.
Crest of John Rhodes's Mill dam . .	406.4	137.5	229.6	422 3
" Crane and Waters dam . . .	423.6	120.3	212.4	405.1
" Walling's dam	448.6	95.4	187.4	380.1
" Rhodes's dam	468.4	75.5	167.6	360.3
Intersection of Main and Burbank Sts. .	477.4	66 5	158.6	351.3
Crest of Lapham's Mill dam	492.7	51.2	143.3	336.0
Underpinning of new engine-house . .	505.3	38.6	130.7	323.4
M. A. Lapham's Mill Office threshold. .	480.6	63.3	155 4	348.1
Intersection of Main and Beach Sts. . .	505.1	38.8	130.9	323.6
" Main St. and Sutton Road, near Machine Shop . .	516.8	27.1	119.2	311.9
Surface of Machine Shop Pond (Nov. 11, 10.15 A.M.)	515.3	28.6	120.7	313.4
Threshold of main entrance to Wheeler's Mill.	542.6	1.3	93.4	286.1
Flashboard of Wheeler's dam	541.8	2.1	94.2	286.9
Intersection of crossroads at Harris's place .	551.5	+7.6	84.5	277.2
Surface of Singletary Pond (Nov. 11, 9.55 A.M.)	548.3	+4.4	87.7	280.4
Intersection of West Millbury and Sutton Roads	561.5	+17.6	74.5	267.2
Underpinning of First Congregational Ch. .	527.4	16.5	108.6	301.3
Intersection of Beach and High Sts. . .	523.6	20.3	112.4	305.1
Underpinning of George Neff's house . .	557.2	+13.2	78.9	271.5
Intersection of High St. and High St. Ave.	515.1	28.8	120.9	313.6
Underpinning of John Hinchcliff's house on High St. Ave.	550.0	6.1	86.0	278.7
Underpinning of St. Charles Hotel . .	514.6	29.3	121.4	314.1
" Burbank Hill School .	508.5	35.4	127.5	320.2
" Samuel Maxwell's house .	584.1	+40.2	51.9	244.6
Intersection of Rhodes and Sycamore Sts. .	428.1	115.8	207.9	400.6
Sycamore St. Bridge over Singletary Brook,	392.1	151.8	243.9	436.6
Surface of Dority Pond (Nov. 17, 9.54 A.M.)	385.8	158.1	250.2	442.9
Surface of water near Gegenheimer's well (Dec. 13, 1887)	362.0	181 9	274.0	466.7
Well A, near old Worcester Road . . .	373.6	170.3	262.4	455.1

MILLBURY WATER WORKS.

ESTIMATE SHEET.

Local Pumping Plan.

	Distribution Piping. ft.	lbs.	lbs.	Cost of Laying.	
12″	7,932 ×	92 =	729,744		
	4,000 ×	85 =	340,000	11,932 at .42 . .	$5,011 44
10″	1,100 ×	70 =	77,000		
	5,810 ×	65 =	377,650	6,910 at .38 . .	2,625 80
8″	1,195 ×	50 =	59,750		
	4,328 ×	45 =	194,760	5,523 at .33 . .	1,822 59
6″	4,940 ×	35 =	172,900		
	17,937 ×	30 =	538,110	22,877 at .28 . .	6,405 56
4″	1,263 ×	24 =	30,312		
	1,353 ×	20 =	27,060	2,616 at .22 . .	575 52
	49,859 ft.		2,547,286 lbs.		$16,440 91

2,547,286 lbs. = 1,137.2 tons + 12.8 tons allowance for waste = 1,150 tons at $35	$40,250 00	
40 tons special castings at $65	2,600 00	
		42,850 00
12″ gates, 16 at $45	$720 00	
10″ " 6 at $34	204 00	
8″ " 8 at $26	208 00	
6″ " 59 at $18	1,062 00	
4″ " 6 at $11	66 00	
		2,260 00
Fire hydrants, 78 at $35		2,730 00
		$64,280 91

Amount brought forward	$64,280 91
Allow for rock excavation	10,000 00
Pumping station, draught chimney, and coal-shed,	5,500 00
One pumping-engine, one boiler with all appliances, set up in running order; capacity 1,000,000 gallons per day	5,000 00
Foundations and connections	900 00
Collecting well	8,000 00
Reservoir on Burbank Hill	9,500 00
	$103,108 91
300 service pipes at $15	4,500 00
	$107,680 91
Add for contingencies, engineering, and land damages, five per cent	5,384 05
Total cost	$113,064 96

PERCY M. BLAKE,
Civil Engineer.

HYDE PARK, MASS., Jan. 28, 1888.

MILLBURY WATER WORKS.

ESTIMATE SHEET.

WORCESTER PLAN.

Distribution Piping.	ft.		lbs.		lbs.	Cost of Laying.	
12″	24,375	×	92	=	2,242,500		
	4,000	×	85	=	340,000	28,375 at .42 .	$11,917 50
10″	1,100	×	70	=	77,000		
	4,040	×	65	=	262,600	5,140 at .38 .	1,953 20
8″	1,195	×	50	=	59,750		
	2,821	×	45	=	126,945	4,016 at .33 .	1,325 28
6″	7,697	×	35	=	269,395		
	17,288	×	30	=	518,640	24,985 at .28 .	6,995 80
4″	1,263	×	24	=	30,312		
	1,353	×	20	=	27,060	2,616 at .22 .	575 52
	65,132				3,954,202		$22,767 30

3,954,202 = 1,765.3 tons + 14.7 tons allowance for waste = 1,780 tons at $35	$62,300	
45 tons special castings at $65	2,925	
		65,225 00
Gates		3,000 00
80 fire hydrants at $35		2,800 00
		$93,792 30
Add for rock excavation		15,000 00
		$108,792 30
Reservoir on Burbank Hill		16,000 00
		$124,792 30

Amount brought forward	$124,792.30
300 service pipes at $15	4,500 00
	$129,292 30
Add for contingencies, engineering, and land damages, five per cent	6,424 62
	$135,716 92
Deduct cost of piping from Quinsigamond Village to town line	21,476 18
Total cost	$114,240 74

COST OF PIPE LINE IN WORCESTER.

9,800 feet of 12-inch × 92 lbs. = 402½ tons at $35 per ton	$14,087 50
10 tons special castings at $65	650 00
Laying 9,800 feet at .42	4,216 00
Rock excavation	1,500 00
	$20,453 50
Add five per cent, as before	1,022 68
	$21,476 18

PERCY M. BLAKE,
Civil Engineer.

HYDE PARK, MASS., Jan. 28, 1888.

To John Gegenheimer, Moses W. Wheeler, L. L. Whitney, Irving B. Sayles, George C. Webber, *Committee on Water Supply and Drainage, Millbury, Mass.*

Gentlemen, — The subject of sewerage and drainage for the town of Millbury is an interesting one, although it may be said that its consideration at this time cannot be urged on the ground of an immediate necessity.

To understand the importance of systematic drainage, the results obtained, and the effects produced by the construction of a properly designed sewerage system, must be considered.

First, a properly designed system of sewerage includes provision for carrying off rain-water from the streets and low places adjoining, and the domestic and manufacturing wastes which must otherwise be discharged into natural water courses, or temporarily stored in cesspools or other receptacles, and removed by hand as often as occasion requires; either process of disposal being inconvenient, and liable to create an injury or offence to individuals and the public in general.

Second, to provide for the removal of surface waters requires the reconstruction of street grades and surface channels, thus securing a noticeable improvement in the alignments and cross-sections of the public highways and avenues of travel. Such changes necessitate the re-adjustment of fences and private entrances, and the re-grading of lawns and dooryards, with the result of greatly improving the appearance of all private property, and consequently the village in general.

Third, where a public water supply is introduced, the construction of sewers makes it practicable to use water freely and in greater quantities than is ordinarily possible where common cesspools receive all the wastes.

Advantages of the kind named above are, however, expensive to obtain; and, as in the case of all other public improvements, the expediency of providing them should be

considered in connection with the necessity suggesting their adoption.

The Centre Village and Bramanville, possibly, are the only sections of the town which at present should be included in a study of this kind; and these two sections may be treated as entirely distinct from each other.

The surface drainage of Bramanville now passes off into the Singletary Brook, although no attempt at systematic relief from storm water and melting snow has been made. It would undoubtedly be of some advantage to this territory to adopt a well-defined grade for the main street, so that travel would not be inconvenienced and made difficult in wet weather, as it now is.

The construction of a sewer through this main street would be such an expensive undertaking, and the advantages to follow so slight, that it would be unwarrantable at present.

The rapid fall of the Singletary Brook from Wheeler's Mill pond to the meadows adjoining Sycamore Street would thoroughly remove any matters which might be discharged into the stream in small quantities, and thus prevent them from becoming a local nuisance.

The manufacturing wastes now thrown into this brook visibly affect the water as it passes at a sluggish rate through the meadows adjoining the Blackstone River, but these wastes are many times greater than the combined domestic wastes of the entire village of Bramanville.

Any plan for the future sewerage of Millbury should, however, include a permanent provision for the Bramanville section, on the assumption that a sewer of modern construction will some day be laid through the main street of that village.

The territory east of the Blackstone River, forming the main village of Millbury, is irregular in its contours, but not difficult to drain.

I have prepared a plan showing in a general way the arrangement of sewers best calculated to effect the proper drainage of this territory.

No attempt has been made to give all the details as to sizes, grades, etc., as this can only be properly done after a detailed survey of each street for that special purpose.

A plan of sewerage contains two distinct provisions: one, the system of receiving drains or channels; the other, the method of disposing of the liquids and matters received.

The former of these provisions becomes simply a matter of study of details, while the latter in many cases is one of very great importance.

This importance is due to the fact that the discharge of the drainage collected from a settled territory is liable to affect the rights of other people and populations; to become an annoyance; to depreciate the value of surrounding property; to vitiate otherwise pure air, and thus endanger health.

The Public Statutes of the State prohibit the discharge of sewage matters into any water-course from which a supply of drinking-water for public use is taken at a point below and within twenty miles of such discharge; and the supervision over such water-courses is given to the State Board of Health for the purpose of carrying into effect the protection afforded by the Statutes.

It is evident, from its present condition, that the Blackstone River does not come under the prohibition, although it was proposed by J. H. Shedd in 1868 as a suitable source of supply for the city of Providence, R.I.

The town of Millbury can discharge its sewage into the Blackstone River, provided it first removes the offensive and polluting properties therein; so that, after its discharge into said river, either directly or through its tributaries, it shall not create a nuisance or endanger public health.

This is the phraseology of the legislative Act[1] directing the city of Worcester to improve its method of sewage disposal; and certainly the town of Millbury is entitled to the same privilege.

There are various methods of purifying, as it is termed,

[1] Chap. 331 of the Acts of the year 1886.

the discharge of a system of sewers. A natural and very proper way is to conduct the sewage to a level area of porous ground, in which the water level seldom or never rises above a plane eight or ten feet below the surface, and there distribute it uniformly over the ground through shallow surface channels.

By this method quite a portion of the liquid is evaporated; most of the remainder disappears by settlement into the soil, undergoing purification as it descends; and the remaining solid matters are disintegrated and absorbed by vegetation, or rendered innocuous by combination with the soil.

The area of land which is devoted to this purpose must be divided into two or three parts, and treatment applied to but one part at a time; thus enabling the other land to become dried and fitted for treatment in its turn.

This method is particularly applicable to villages and towns of moderate size; and for its simplicity and efficiency, where the conditions are favorable, it is preferable to any other method.

A successful instance of this kind may be seen in the town of Bridgewater, Mass., where the sewage of the State Normal School is disposed of on a convenient tract of land lying on the edge of the village. Another instance can be seen in the town of Medfield, where the distribution of a small amount of sewage over a prepared field has so far worked effectively, and without creating a nuisance.

The plan recently proposed and recommended to the city of Worcester involves a different method of purification. It proposes to precipitate or settle in large tanks all solid matters contained in the sewage, by the use of chemicals which shall in effect neutralize all tendency to putrefaction in the resulting liquid, and then discharge the latter directly and freely into the Blackstone River.

This method, which is being successfully applied abroad, will undoubtedly prove efficient, if intelligently applied and operated, in the case of Worcester; and the result will be a

measurable improvement in the appearance and quality of the river water as it flows through Millbury.

This latter method is almost wholly a mechanical one, involving an expensive plant and considerable machinery; and its management is expensive, requiring constant attendance and much consumable material in the shape of manufactured chemicals. Yet there are cases where the existing conditions will compel the adoption of a precipitation plan.

There are really but three ways of disposing of the sewage of Millbury. One is, to discharge it directly into the Blackstone River at a convenient point below the village; another is, to receive and distribute it over the surface of a proper area of ground, allowing the filtered water resulting from such a process to flow off into the nearest stream; another is, to partially purify by chemical precipitation, and then discharge it into the river.

I have no hesitation in recommending a combination of the first two methods, making the treatment on the ground the primary method, and providing for a discharge into the river when for any reason the other method needs relief or temporary suspension.

By referring to the map submitted herewith, you will understand the outline of this plan.

First, it is proposed to collect the drainage of Bramanville (ultimately) in a sewer laid through the main street to a point in Elm Street near the Blackstone River. The territory contributing to this sewer I have called the Bramanville district.

Second, it is proposed to collect the drainage of West, Summer, Grove, Cherry, and Waters Streets, the lower portion of Elm Street, east of the Providence and Worcester Railroad, and River Street, by means of proper sewers at a point near the Providence and Worcester Railroad, and on the east bank of the river. This territory I have called the River-street district, as the principal low-level sewer is to be laid in River Street.

Third, it is proposed to collect the drainage of the south and east sections of Miles Street, Main Street from West Street to Elm Street, Church Street, Canal Street, and Elm Street from a point between Waters and School Streets to Canal Street, at a low point on Canal Street near the Blackstone River. This territory I have called the Canal-street district.

Fourth, it is proposed to collect the drainage of South Main Street from Curve to Maple Streets, Curve, Maple, Coral, and Dublin Streets, at a low point in Providence Street, near Dublin. This territory I have called the Maple-street district.

It is proposed to so unite the Bramanville, River-street, Canal-street, and Maple-street districts, described above, as to effect by the combination a delivery of all the drainage collected at one central point.

To do this, an intercepting sewer can be constructed from Elm Street, near the Providence and Worcester Railroad, over the route shown on the map to the intersection of South Main and Maple Streets. The drainage from the Bramanville and River-street districts will be received in the upper end of this sewer.

The sewer in Maple Street is to be of sufficient capacity to carry all sewage proper to the junction of Maple and Providence Streets. At this point, the drainage of the Canal-street district will be received, and the combined flow will then be conducted through the main outfall sewer of the system, to be constructed in Providence Street, to a point below Simpson's factory, where its diversion and distribution for ultimate disposal can easily be made. There are several low areas below and near this point which can be prepared for surface disposal at reasonable expense, and suitable material in the shape of coarse and fine gravel can be had in the neighborhood.

It is proposed to provide, at the points shown on the map, such storm overflows as may be necessary to relieve the main

sewers of excessive surface water. These overflows can be so gauged as to permit all water necessary for flushing and cleaning to enter the sewers, but no more.

There are no unusual difficulties in the way of carrying out this plan, other than the probability of meeting much rock excavation above the grades on which it will be advisable to construct all the sewers.

The average depth of these sewers should be twelve feet, in order to provide drainage for deep cellars and low spots here and there.

The river crossings may require in one or two cases special provision for flushing, especially if they are depressed to secure passage on the bed of the stream; but such provision could not entail very great expense, and the arrangement ment would not be objectionable so far as its practical operation might be concerned.

It is evident that a close study of all these details will be necessary before the grades and sizes of the various sewers can be decided, but the general features of the plan should be substantially as herein described. It is, of course, to be understood, that, when such detail plans are made, the manholes, light shafts, and flushing valves necessary to make a perfect system of sewerage must be provided and shown thereon.

A reasonable estimate of the ultimate cost of this system of sewerage is $96,000, but such expense would naturally be incurred in instalments. The construction of a sewerage system is in most cases extended over a series of years, such members of the system as may be required to relieve crowded neighborhoods being provided from time to time, as necessity compels.

Thus the natural growth of a village secures to its inhabitants such improvements in drainage as circumstances from time to time require, and by moderate expenditures. If these improvements are made in accordance with a well-designed plan providing for the future and permanent re-

quirements of the population it is to serve, every dollar thus expended is well invested, and there will be avoided the expensive remodelling of sewers, which several of the smaller cities and some of the larger towns in New England will soon be compelled to undertake.

Knowing the favorable opportunities which exist for providing a modern sewerage system for the town of Millbury, it will be of interest to examine the present necessity for the adoption of such improvements.

I presume the expediency of introducing a public water supply has naturally suggested the query, Will not a system of sewerage be a collateral necessity?

I have no hesitation in answering this in the negative, and without any idea of belittling the importance of systematic sewerage.

I believe that reasonable modern improvements should be adopted by every town as fast as the public treasury will allow, and the convenience of the inhabitants require; but to undertake so expensive a project in this case at the present time as the construction of a sewerage system would not be sound policy.

I base my reasons for such opinion on the following facts, which I think you will recognize and fully appreciate: —

First (assuming that a public water supply is introduced and extensively used by the present population), there are no estates on any of the streets surveyed and included in the study, unless possibly a very few between the Town Hall and the river, which are not large enough to allow of the construction of proper cesspools without interference with, or offence to, the occupants of adjoining buildings. The village is in no sense crowded, but is, in fact, very *openly* occupied by its inhabitants.

Second, the introduction of pure water by modern methods removes the greatest objection which can be urged against the existence of cesspools, even of approved construction; viz., that such disposition of waste matters tends, and in

many cases does operate, to contaminate domestic well-waters.

Third, as the function of a sewer is not only to remove waste matters, but also to lower the plane of saturation in the soil, the advantages to follow from the reduction of soil dampness under and around a building must be measured by the opportunity for such reduction.

In the case of your main village, the soil and contours are such that, with the possible exception of the River-street and lower Elm-street neighborhoods, no appreciable advantages would follow in this direction from the construction of sewers.

Fourth, the cost of modern sewers in your case will appear excessive when compared with the modest valuations of the estates to be benefited. If the cost of such sewers were to be largely met by taxation, a burden would be imposed on those who would receive no benefit from the improvement. If the usual method of assessing a large percentage of the cost of the sewers on abuttors were adopted, then the individual burden would cause distress in many cases. I do not think the necessity for sewers exists in Millbury to the degree that will warrant any considerable outlay for construction.

Much improvement in surface drainage can be made at small expense and in instalments; and I advise that grade plans be procured and adopted at once by the town, and that the repairs of street surfaces hereafter be made in accordance with such plans, with a view to securing good surface drainage, and avoiding future expense.

Many towns have adopted this policy, and universal satisfaction has followed in every instance.

Yours respectfully,

PERCY M. BLAKE,
Civil Engineer.

HYDE PARK, MASS., Jan. 28, 1888.

RAND·AVERY·CO.